Mapping habitability around M-dwarfs with ULTRASAT

Sagi Ben-Ami, Param Rekhi

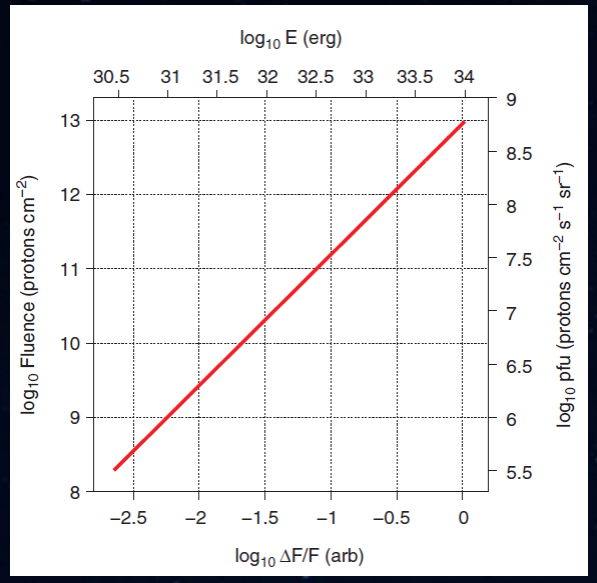
11.1.2023

ULTRASAT
SKYLIGHT TO SPACE

מכון ויצמן למדע
WEIZMANN INSTITUTE OF SCIENCE

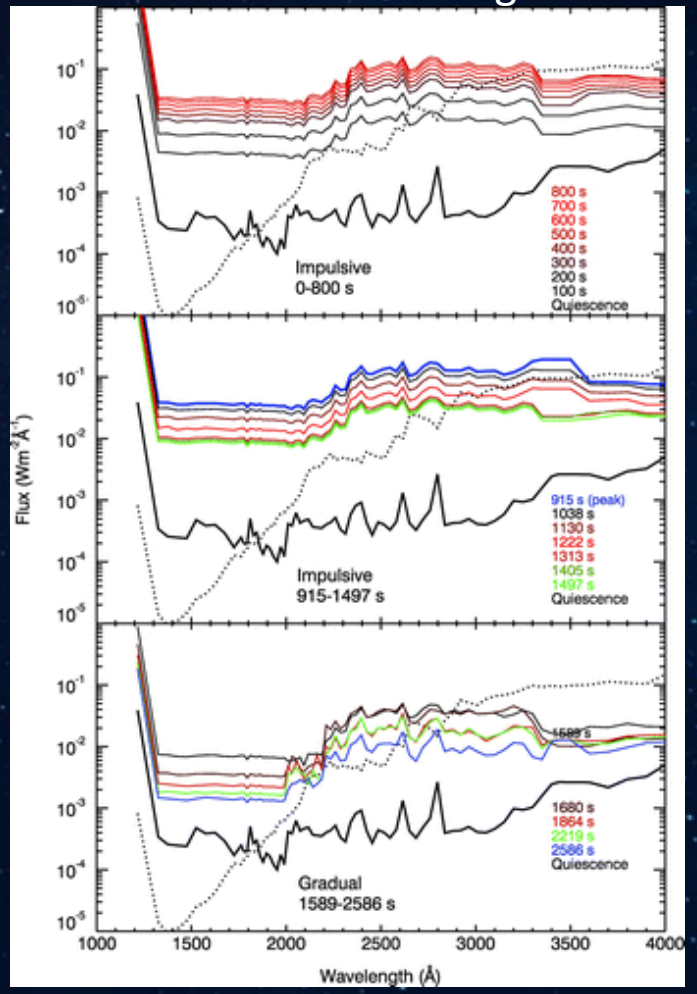
Small Stars Pack a Big Punch

- M-dwarfs exhibit flares with instantaneous flux of up to $\times 10^3$ times their quiescence flux.
- These flares are often accompanies by CME/SEPs (further derivation from the Neupert effect)



Tilley 2019

Segura 2010



M-dwarfs HZ planets are exposed to high energy radiation and high flux of energetic particles.

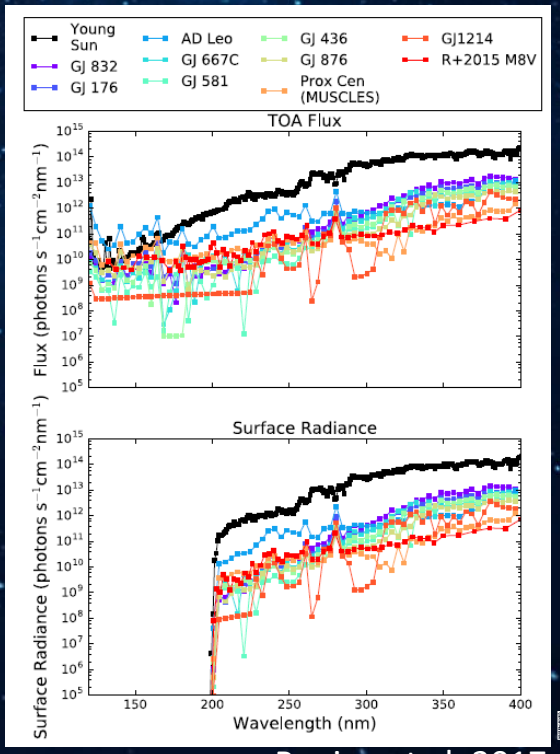
UV Radiation as a stressor

UV radiation can photochemically alter the atmosphere of a planet.

Planetary atmospheric escape can be caused by short wavelength UV radiation that heats the planet's exosphere.

CME/SEPs can erode an atmosphere from molecules providing atmospheric shielding

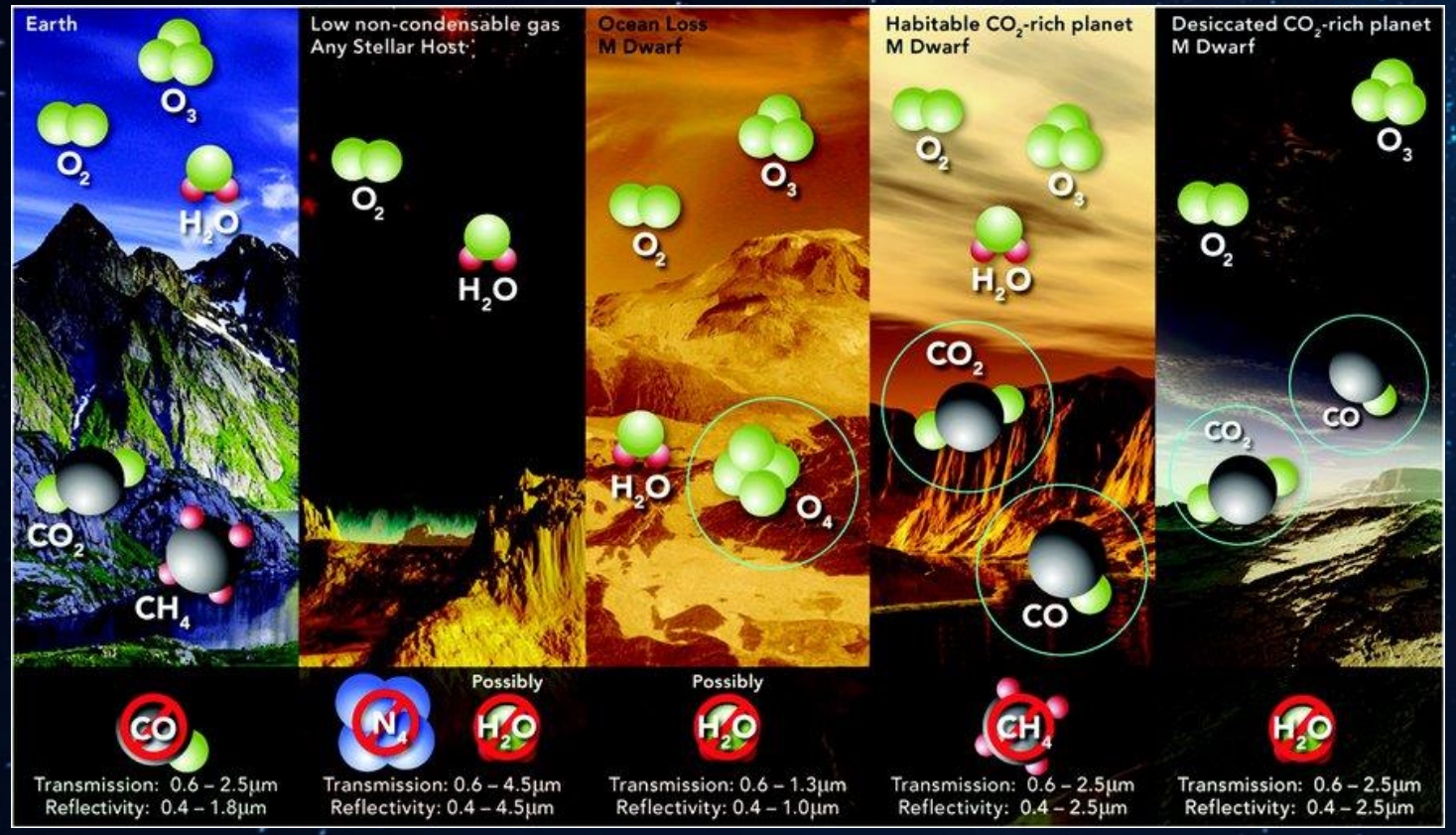
With no atmospheric shielding from ,*e.g.*, O_3, the surface becomes highly irradiated, disintegrating complex molecules, and causing an increased rate of mutation.



Ranjan et al. 2017

UV Radiation environment and planetary atmospheres

Can result in a abiotic source of bio-signature molecules such as O_2.



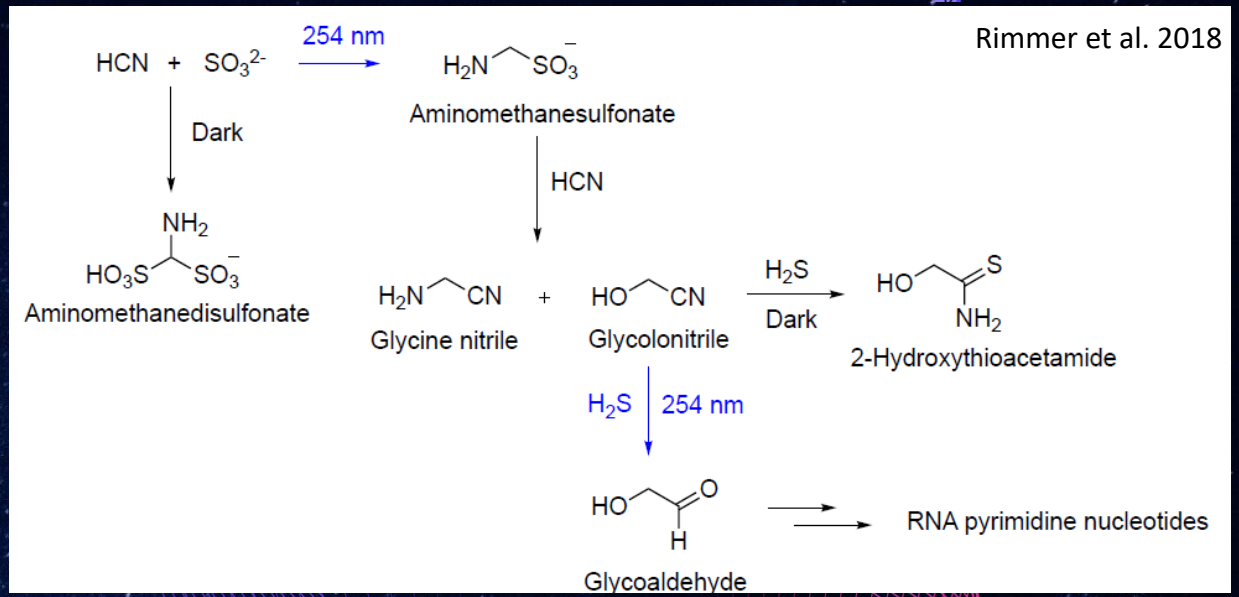
Meadows et al. 2017

UV Radiation: Energy source for prebiotic chemistry

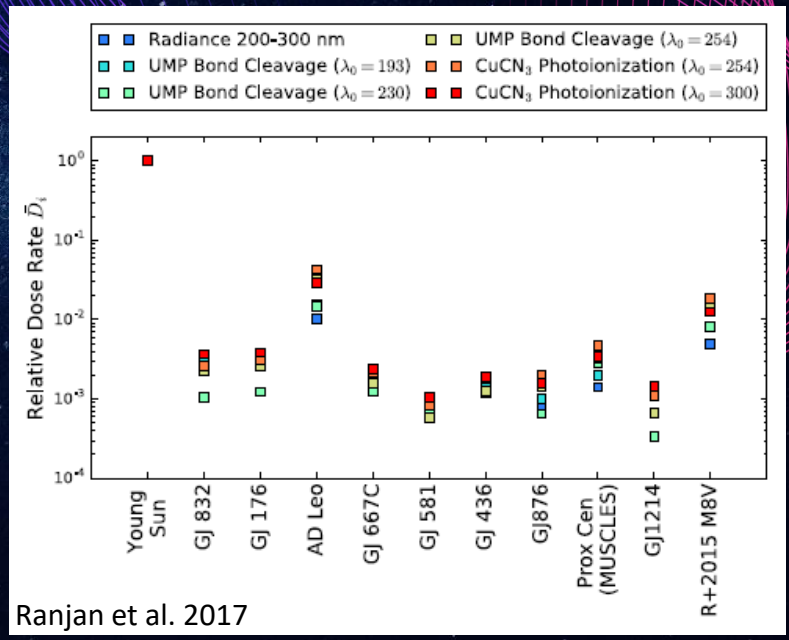
NUV required for prebiotically chemical networks to selectively achieve high yields of nucleosides and amino acids, in conditions that are realistic for early Earth.

The photochemical process need to overcome the yield from thermal processes.

Quiescent emission from M-dwarfs seems to be orders of magnitude too low.



Rimmer et al. 2018



Ranjan et al. 2017

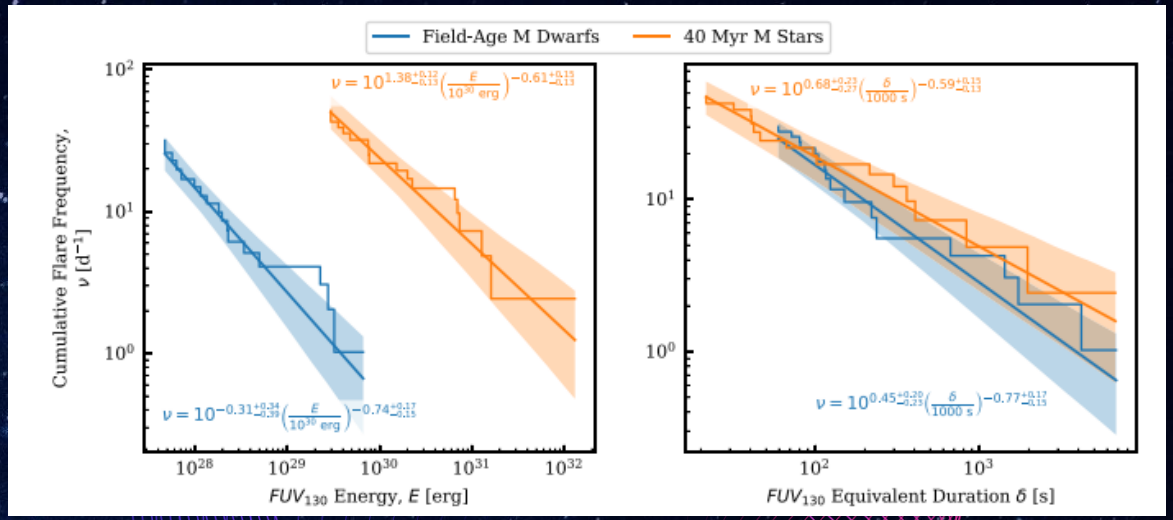
The Flare Frequency Distribution of M–dwarfs

Several efforts have been targeting dM activity in the UV in the past decade (MUSCLES – K. France, HAZMAT – E. L. Shkolnik).

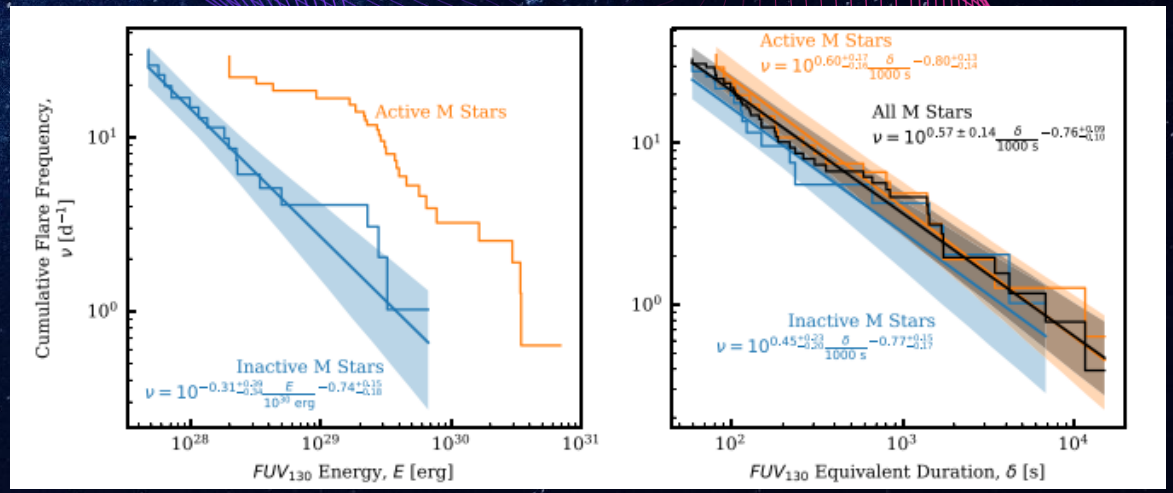
Several surveys have taken long baseline observations of dM stars and allow us to measure the FFD (GALEX, TESS)

Two CubeSats are targeting long baseline observations in the UV for specific targets (CUTE, SPARCS).

Loyd et al. 2018

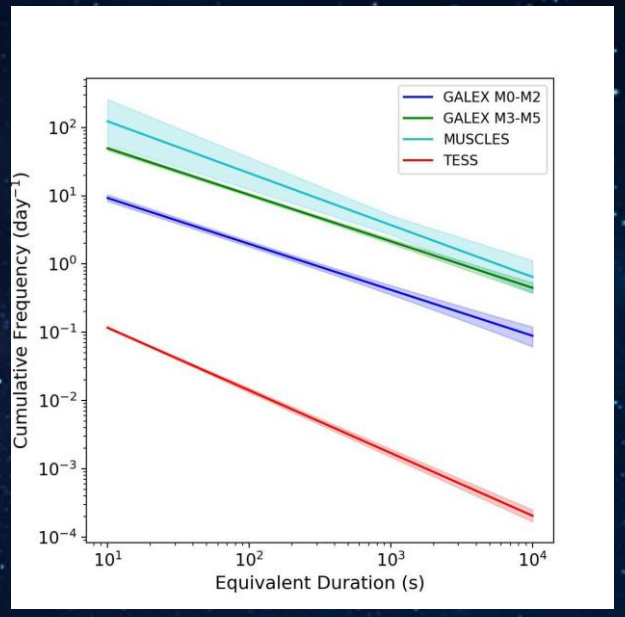


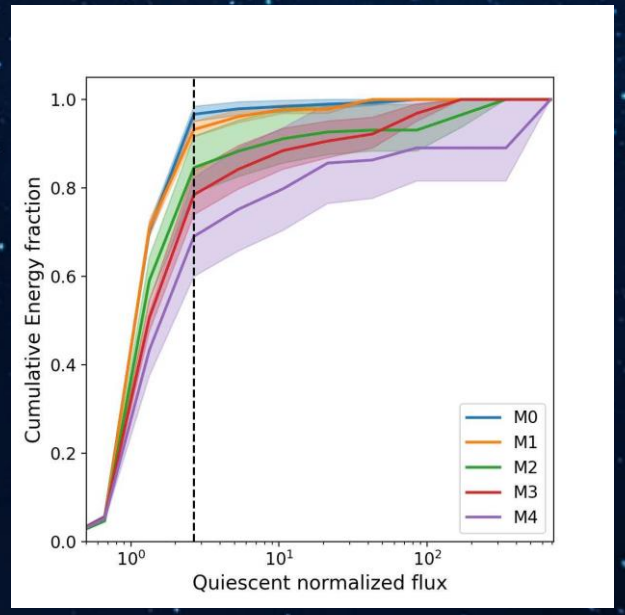
Loyd et al. 2018



The Flare Frequency Distribution of M-dwarfs

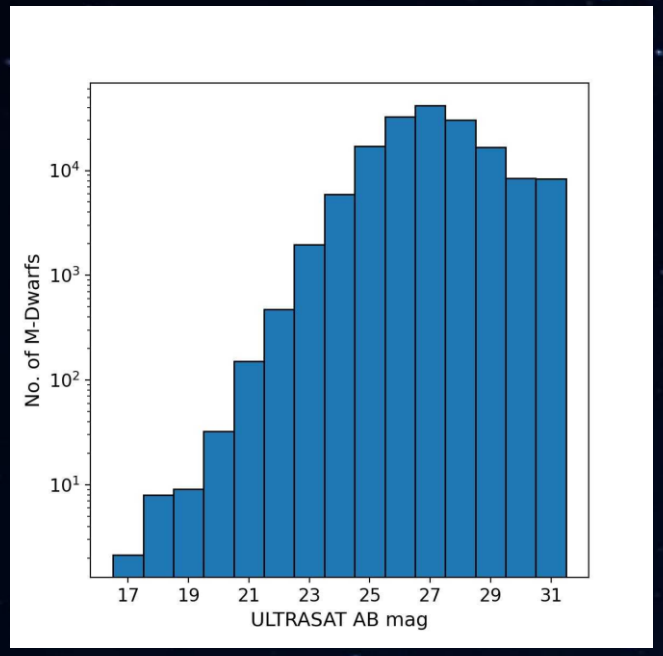
- Results so far indicate FFD is different at various bands.
- Due to limited data sets, we cannot determine the FFD in the UV bandpass for frequencies below $\sim 10^{-1}$ day.
- Limited dataset specifically for late type M-dwarfs.
- **<u>ULTRASAT will allow us to monitor single/several fields continuously/at high cadence in the NUV.</u>**

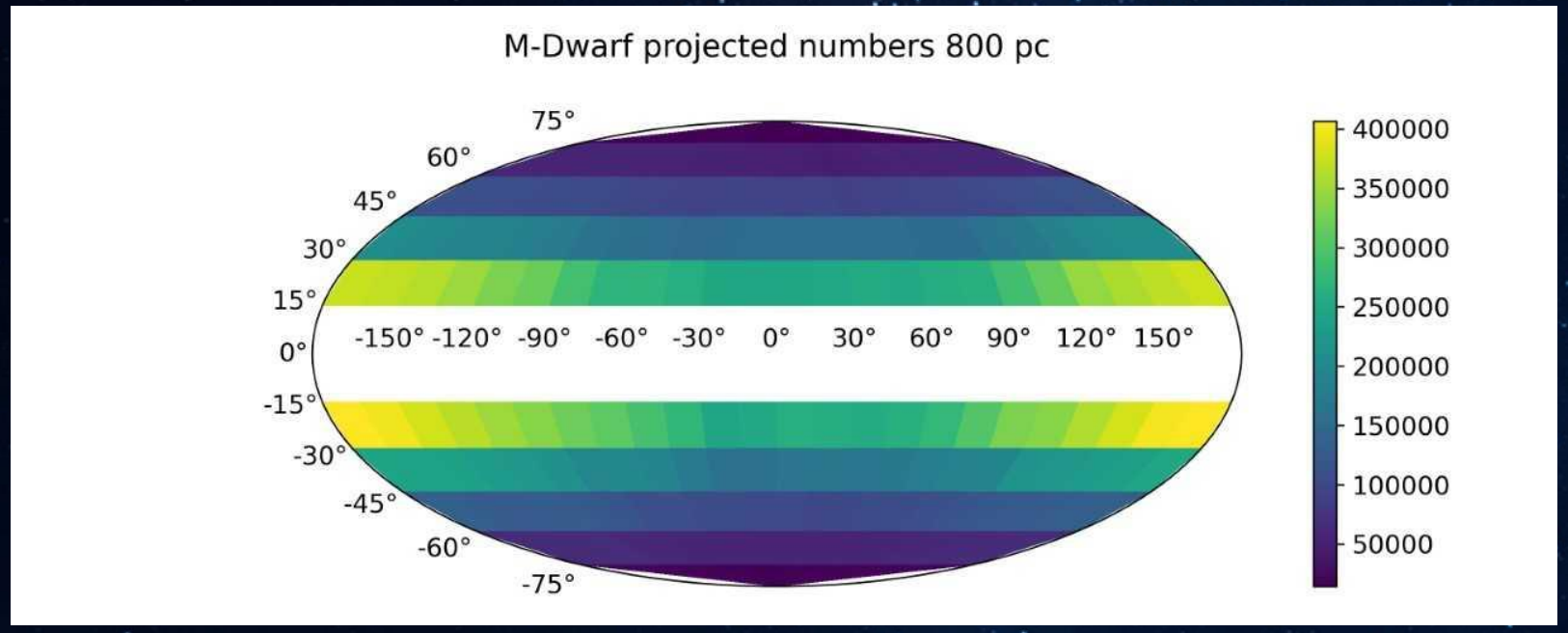




M-dwarf NUV Flares: The Movie

With in ULTRASAT instantaneous FoV we can find thousands of M-dwarfs in each exposure.





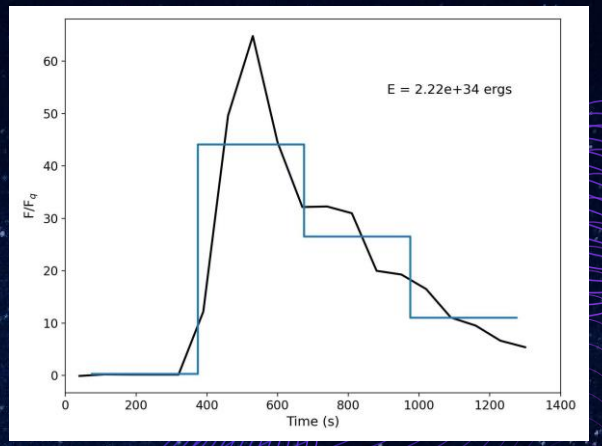
~ 75 M-dwarfs to be detected in each 300s exposure due to enhanced activity (25 being M0-M2.; 50 being M3-M6).

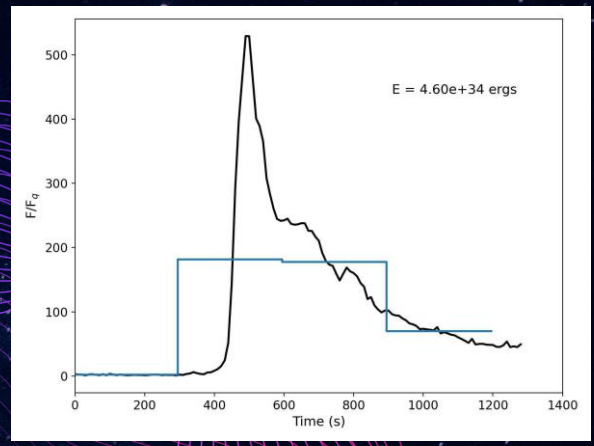
An average of 13 (7) M0-2 (M3-6) sources detected in quiescence (thousands in co-adds).

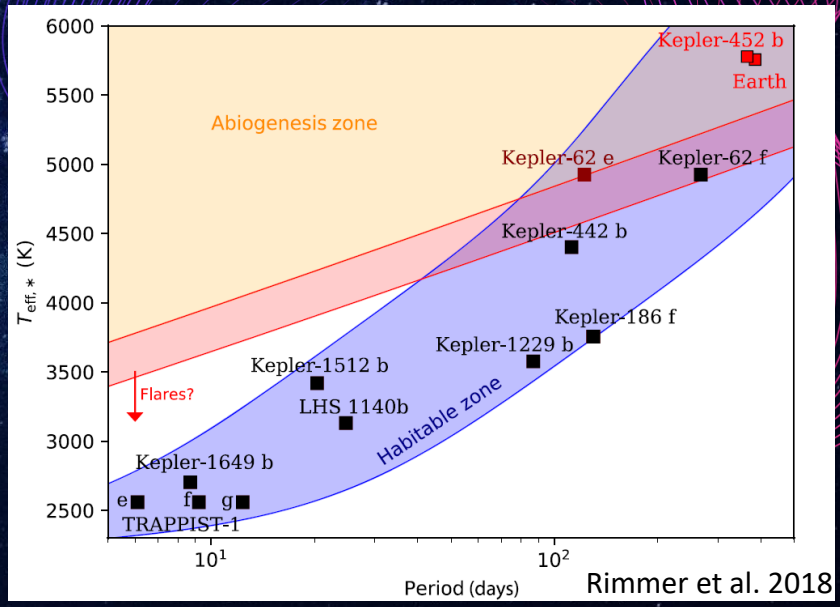
Flares as seen by ULTRASAT

While ULTRASAT long integration time raise challenges in resolving a flare profile, it will allow us to measure the FFD for energetic rare events.

ULTRASAT will allow us to create a stellar atlas of UV habitable zone that will guide us in future studies of Exoplanets and their atmospheres







Rimmer et al. 2018